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# STUDY OF THUNDERSTORM PROCESSES IN THE AZERBAYDZHAN SSR

_USSR_

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# STUDY OF THUNDERSTORM PROCESSES IN THE AZERBAYDZHAN SSR

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[Following is the translation of an article by A. S. Alizade entitled "Postonovka Kompleksogo Issledovaniya Grozovykh Protsessov v Azerbaydzganskoy SSR" (English version above) in Izvestiya Akademii Nauk Azerbaydzhanskoy SSR, Seriya Fiziko-Matematicheskikh i Tekhnicheskikh Nauk (News of the Academy of Sciences Azerbaydzhan SSR. Physico-Mathematical and Technical Sciences Series), Vol 2, Baku, 1960, pages 101-106].

Development of effective anti-thunderstorm measures to protect power lines and other objects calls for a knowledge of the regularities in the development of the lightning mechanism and for determination of its basic parameters.

Earlier investigations in various countries, including the Soviet Union and particularly the Azerbaydzhan SSR, have produced much factual material for understanding the individual aspects of thunderstorm phenomena. At the present time, interest in lightning has grown because of the great damage done by it to high-tension lines. It has been established that there is a wide gap between calculated data and the true facts of breaks in power lines because of lightning. The inadequacy of the present methods of designing protective measures and of the knowledge of the lightning-bolt mechanism has become obvious, inasmuch as the present thunderstorm protective methods are based on inaccurate data and often on erroneous concepts of the nature of a lightning bolt.

In response to practical demands for thunderstorm protection, and also because of the necessity of refining individual parameters of lightning discharge and of establishing their relations and the regularities in the lightning process, we are building a field laboratory for a comprehensive study of thunderstorm processes under natural conditions. This laboratory will be the first of its kind in the Soviet Union.

Because of a number of conditions favorable to observations, the laboratory site has been selected in the Shemakha Observatory area. Here, at an elevation of 1500 m above sea level, the main laboratory has been built, along with three metal masts 20 m high. The laboratory is surmounted by a 4.5 m metal tower for optical

instruments and visual observation.

A broad program of study of thunderstorm phenomena has been laid out and recording and measuring methods have been worked out.

The laboratory schedule includes the following fields of study to be started with the 1960 thunderstorm season, in a definite sequence.

<u>Study of the Formation of Thunder Clouds and of Their Electric Nature in the Complex of All of the Accompanying Electric Processes of the Atmosphere</u>

The problem of electric characteristics of thunder clouds is not new. Their study has been confined chiefly to physicists, with results not related either to the discharge process or to the electric characteristics of the cloud-earth interval.

Furthermore, because of the substantial shortcomings in the then-current method of investigation, such a probing the clouds with balloons, the extant data on the electric structure of a cloud cannot be regarded as satisfactory, either qualitatively or quantitatively. A determination of the electric structure of a cloud (its electric field gradient, the magnitude and sign of its potential at any point of the cloud) should be done with modern mensuration methods, such as radio-sounding, which is being used in our study. It was applied by V. I. Arabadzhi in his 1958 study of thunderstorm clouds, in Minsk. [4]. A shortcoming of this technique was the lack of a transmitted signal showing the antenna's deviation from the vertical, in the cloud, as well as an undetermined position of the balloon in it.

In our installation, these shortcomings will be eliminated by adding a unit for transmitting the signal marking the deviation from the vertical. The sounding balloon position in a cloud will be determined by a radar similar to that used by the Meteorological Service.

Measuring and recording the electric-field gradient and the electric resistence of the air, both during the formation of storm clouds and at the instant of and immediately following a lightning discharge, will be done with special instruments manufactured in our laboratory. In the principle of their performance, these instruments are not different from those used in measuring the same atmospheric conditions in fair weather. An advantage of our instruments as compared with the earlier ones is their wide measuring range and a track-oscillograph for recording the readings on film. A brief description of these instruments is given below.

A dynamic field meter is used in measuring the electric field gradient. Its transmitter is an electrostatic generator with four measuring plates and a grounded rotary disc. The transmitter signal is dispatched to a tube amplifier whose outlet has a microammeter graduated into volts per one meter (v/m). The instrument has three measuring ranges: up to 250; 1500; and 7500 v/m. Its reading can

be recorded on tape, by means of the track-oscillograph.

Two cylindrical condensers are used for measuring the air electroconductance; one of them is positive, the other negative. Air is driven through a charged condenser by means of a fan; as a result, the condenser's charge is reduced depending on the electroconductance of air.

Readings of the positive and negative air conductance will be recorded by means of a track-oscillograph on a single photo-film, along with the value of the electric field gradient. The simultaneous recording of both measurements will make it possible to determine the relationship between the electric field gradient and the electroconductance of the air.

Study of the Mechanism of the Discharge Development and of Factors Affecting It

The main aspect of the problem of thunderstorm processes in the establishment of regularities in the mechanism of a thunderbolt at all of its stages and of its relationship with the electric conditions in a cloud and in the cloud-ground air interval. Despite the voluminous material on the development of a lightning channel, the working out of a perfect method of designing anti-lightning measures calls for substantial supplementary data.

A further study of the lightning stroke should be conducted for the purpose of refining material on hand in the light of most recent technical achievements, as well as for determining the relationship between individual parameters and processes of the thunderstorm phenomena. Thus, a comprehensive method of study is necessary. Accordingly, the use of optical and electric instruments is contemplated in the study plan of our laboratory. Nocturnal thunderstorms are of particular interest in such a comprehensive study, because nocturnal lightning bolts will be recorded optically and electrically.

Of great interest in the study of the relationship between the development of a lightning stroke and the electric conditions in the discharge interval is a comprehensive investigation of the items measured, having to do with the development of the channel as well as with the electroconductance and the electric field gradient for the discharging medium.

Anticipated as a result of this research is information on the qualitative and quantitative characteristics for the development stages of a direct (leader) and a return stroke. Panoramic pictures of leaders will promote a complete understanding of their development.

One of the main problems in the theory of lightning is an explanation of the spark-through mechanism for the leader stage of the advanced discharge impulse. An analysis of optical data has shown that the leader of a first impulse, as recorded on some Boysgrams, is developed in steps. On that basis, a number of students (Schonland, Meek, Chipor, Bruce, Flowers, and others) have advanced theories and assumptions of a step-by-step development of discharges;

such theories ruled out a continuous development of discharges.

In our 1948 study, we obtained Boys-grams of discharges with both step and continuous development for the first impulse leader; in the latter instance, the entire cloud-ground air gap was pierced by a continuously moving streamer [1].

The Boys-grams of such discharges contradict theories and assumptions of the above-named authors on an exclusively step-like character of their development.

However, a full understanding of the development of a discharge will require more extensive factual material of optical study as well as information on the nature of the discharge development.

Another important problem is a determination of the form of the leader head, of the spark-through mechanism, and of the development of a return stroke streamer in the ionized channel of the leader.

Because of the scarcity of material, the problem of afterglow of the return streamer remains unsolved.

In addition, a computation of the electromagnetic field of a lightning channel requires information on the connection between the amplitude of a lightning current and the speed of development of the return stroke [6].

A clarification of these subjects requires the application of more advanced optical instruments and rapid recording electronic oscillographs.

Optical study will be done with two photo-cameras with timed panoramic attachment. One of them has two drums, two of which rotate at different speeds (linear velocity of one drum is of the order of 30-40 m/sec, while the other's velocity is four times lower) and the third is stationary. Photo-film, 3.5 cm wide, is wound up on these drums, with the magazines placed inside the apparatus. The film in each magazine lasts for 10 exposures. The drums are installed within the camera with five Yupiter [Jupiter] -3, f=1:1.5 objective lenses. The angular range of the camera is about 200°; a discharge is recorded by the two moving and one stationary films. Slower stages of a discharge development will show on the slow moving film; the rapid ones -- on the fast moving.

This photo-camera has been constructed from the author's design. It differs from the preceding ones by its convenience, simplicity of design, and by the fast Yupiter-3 lenses.

In order to obtain clear images of fast discharge stages, the present lenses will be replaced by quartz ones whose use will make it possible to study the development mechanism of dim, little-known discharge elements. Especially interesting will be the study of the qualitative and quantitative characteristics of the development of a leader head in air and of the afterglow phenomena.

The second panoramic timed camera is intended for optical study of the return stroke stage. This camera has been designed after the Boys camera.

It has a verical disc attached to the electromotor shaft, with

two Yupiter-3, f=1:1.5 lenses fitted into the front wall of the camera. The film is loaded into special round magazines with a safety shutter allowing reloading in daylight. The magazine is attached to the disc and rotates at speeds up to 4000 r.p.m. Boys-grams taken with this camera afford the study of the little-known stage of return stroke with its afterglow effect.

Parallel with the optical study, recording of discharges with electron oscillographs will be carried out. Upon our order, the Experimental Factory of the All-Union Electrotechnical Institute manufactured two unique cathode oscillographs which make it possible to unroll over the whole screen a process lasting but a microsecond. These oscillographs will afford means of recording the most rapid stages in the process of development of a discharge, which have hitherto remained obscure (such are stages occurring at the wave front of the return stroke current, etc).

In order to study the magnitude and nature of supercharges induced in transmission lines by lightning strokes to the ground, high masts are erected with antennae strung on them at different heights (10-15 m). Four electron oscillographs are attached to the antennae.

The oscillograms so obtained will be instrumental in the study of the wave form in induced supercharges, the frequency of discharges, the polarity of their impulses, their duration, the interval between them, etc, thus complementing the earlier study carried out in various countries.

Study of Parameters of a Direct Lightning Stroke

Study of direct lightning stroke is of great theoretical and practical interest. Material on hand consists mostly of magnetic measurements of lightning striking transmission lines. The measured lightning currents and the (di/dt) slope do not reflect true values because lightning currents on lines have several branches and are distorted by the effect of reflected waves.

Out of a total of about 6000 measurements of direct lightning current in lines, made in various countries [2], only a few measurements of such currents and their slope were performed on discharges striking isolated lightning protectors.

For that reason, the future study of parameters of a direct stroke should be done on isolated lightning rods, in order to obtain more valuable material.

For that purpose, the laboratory construction schedule includes a lightning rod, 300-400 m high above ground, obtained by stretching a metal cable from the ground to a balloon. The probability of a lightning stroke at such a height is considerably increased.

Under our field laboratory conditions the number of direct strokes is about 15-20 a year, at the lightning rod height of 400 m (according to Imyanitov's data [5]. The study of parameters of direct lightning stroke will begin in 1961.

Obtaining Statistical Data on the Intensity of Thunderstorm Activity

In calculating the thunderstorm resistance of objects in a storm area, only the number of stormy days per year has been hiterhto considered. It has been shown elsewhere in our works that such an approach does not reflect the true thunderstorm hazard. However, for lack of necessary data, the calculation of thunderstorm resistance is still based on the number of stormy days per year.

That purpose would be better adieved by data on the total thunderstorm time during a year and on the intensity of thunderstorm activity for a given area (the number of discharges from a cloud to the ground, per a thunderstorm) [3].

At the present time, meteorological stations do not conduct such detailed observations of thunderstorms. This results either in inadequate lightning protection or else in over-isolation of transmission lines.

Data obtained from observations in our field laboratory will provide specific corrections to those obtained at meteorological stations, and a means for designing more effective lightning prevention measures.

Our observations will be carried on visually as well as by means of a thunderstorm-meter which we have devised and constructed.

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